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Vol. 1. Part 1 **OCTOBER, 1919** **Number 1**

BULLETIN
OF THE
NATIONAL RESEARCH COUNCIL

THE NATIONAL IMPORTANCE
OF
SCIENTIFIC AND INDUSTRIAL RESEARCH

By

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PUBLISHED BY THE NATIONAL RESEARCH COUNCIL
OF
THE NATIONAL ACADEMY OF SCIENCES
WASHINGTON, D. C.
1919

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of the
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The Bulletin of the National Research Council

presents contributions from the National Research Council, other than proceedings, for which hitherto no appropriate agencies of publication have existed.

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BULLETIN
OF THE
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THE NATIONAL IMPORTANCE OF SCIENTIFIC AND INDUSTRIAL RESEARCH

THE PURPOSE OF THE NATIONAL RESEARCH COUNCIL

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By George Ellery Hale
Honorary Chairman

> When a violent revolution occurs amongst a highly civilized people, it can not fail to give a sudden impulse to their feelings and ideas. This is more particularly true of democratic revolutions, which stir up at once all classes of the people, and at the same time beget high ambitions in the breast of every citizen. The French made surprising advances in the exact sciences at the very time when they were completing the destruction of the remains of their former feudal society; yet this sudden fecundity is not to be attributed to democracy, but to the unexampled revolution which attended its growth.—*de Tocqueville, Democracy in America.*

The most brilliant period in the history of science in France followed close on the heels of the Revolution. In the stirring days of the First Empire, the Paris Academy of Sciences comprised in its membership the strongest group of investigators ever assembled. The intellectual life of the nation had been quickened to its depths, and in spite of the devastation of the Terror, which included Lavoisier among the victims of the guillotine, science attained a prestige far higher than it had ever known during the tranquil days of the old régime. The nation instinctively turned to the Academy for advice and assistance in the initiation of many new enterprises, and ministers, parliaments, administrators and state assemblies often sought its aid and accepted its decisions. The leaders of the Revolution, and subsequently Napoleon himself, reëstablished the old Academy on firmer foundations, and accorded it privileges never experienced under the monarchy. The distinguished company of scientific investigators included in the expedition to Egypt proved that Bonaparte, who was soon to attain supreme power, fully recognized the value of science to the state.

The establishment of our own National Academy of Sciences during the Civil War, and its activities in the study of military and industrial problems for the Government, affords another illustration of the effect of war in promoting scientific research. The chief events of this period have been sketched in an address before the National Engineering Societies, and need not be repeated here.[1] Nor is this the place to enter into a discussion of the relationship between science and war. Suffice it to say that de Tocqueville's statement quoted above probably applies, not merely to revolutions, but also to such wars as that of the present day. The intellectual stimulus accompanying great upheavals, however they originate, finds expression in unusual achievements in science.

At the present moment we are confronted by a fact which requires no general demonstration to bring it into view: throughout the civilized world the national importance of science and research is appreciated as never before. Even if there had been no intellectual stimulus, the present great war would have forced science to the front. In the first days of the conflict, the nations of the Entente were faced by problems soluble only through the aid of scientific research. Statesmen whose exclusively classical training had afforded them little or no means of appreciating the significance of science were compelled to summon investigators to their aid in order to overcome difficulties demanding instant solution. The question of manufacture, serious as it was, frequently held second place to the necessity for research. Thus in England it was evidently impossible for the glass factories to produce the special kinds of optical glass needed for periscopes, gunsights, field glasses, and many other military instruments, until the methods of making these glasses, previously worked out in Germany, had been rediscovered by British investigators. So with scores of other problems forced upon the nation under the stress of war. Scientific research was the first requisite, and both men and funds must be provided without delay.

No intelligent statesman, however, could meet such a situation without appreciating its obvious implications. Successful research demands trained investigators, and these cannot be produced in a day. It also demands adequate provision of funds, not merely during the feverish moments of war, but throughout those long periods of calm, when the foundations that underlie the success or failure of a nation are laid. The British people, in spite of wholly inadequate appreciation of science by former leaders of their government, have never failed to produce investigators of the highest type. Men like Newton, Darwin, Faraday, and Kelvin have appeared in unbroken sequence from the earliest times, and fortunately there are no present indications that this splendid succession will be broken. The great Cambridge school of mathematical physics, powerfully supplemented during nearly half a century by the Cavendish Laboratory, has been a foremost agency in the development of men qualified for research. But the means at the disposal of the universities have been sadly limited, and the government has persistently refused to recognize that no public funds are more productive than those that are devoted to advancing knowledge.

The recent appropriation of one million pounds by the British Government for the promotion of scientific and industrial research, and the large sums provided for the same object by the Governments of Canada, Australia, and other British colonies; the establishment of a great national laboratory of chemistry and physics in Japan; and the similar undertakings already initiated in France and Italy, and projected in Belgium, are significant signs of the times. It is plain that we in the United States must not fail to profit by an opportunity which other nations have already seen and grasped. Fortunately the way has long since been prepared, and the initial steps have been taken in a truly national movement for the advancement of science and research.

The National Academy of Sciences was established by Act of Congress, signed by President Lincoln on March 3, 1863. Its charter states that "the Academy shall, whenever called upon by any department of the Government, investigate, examine, experiment, and report upon any subject of science or art." Under this provision, the Academy dealt with many military problems during the Civil War, and since that time it has frequently been asked by the President, by Congress, and by heads of Government Departments to report on scientific and technical questions. In April, 1916, when the unwarranted attack on the *Sussex* had brought our relations with Germany close to the breaking point, the Academy offered its services to the President. He at once requested that steps be taken to organize the research agencies of the country, not solely with respect to the necessities of possible war, but also because of the importance of developing and utilizing them more effectively under peace conditions. This led to the establishment in September, 1916, of the National Research Council, a federation of governmental, educational, privately endowed, and industrial research agencies, resting upon the charter of the National Academy, and extending the scope of its activities into every branch of the mathematical, physical, and biological sciences, and their applications to engineering, medicine, agriculture, and other useful arts.

Thus our National Research Council differs fundamentally in several respects from the Advisory Councils for Scientific and Industrial Research recently established by the British, Australian, and Canadian Governments, though its general objects are similar to theirs. Those Councils are branches of the Government, with officers appointed by the party in power and thus subject to political influences and exigencies. The National Research Council is closely connected with the Government, through the charter of the Academy and the Executive Order issued by President Wilson on May 11, 1918, which provides for the coöperation of Government Departments, and for the appointment by the President of representatives of their scientific and technical bureaus to membership in the Research Council on the nomination of the National Academy of Sciences. The constitution of the Research Council is determined, however, by the National Academy, and this assures its scientific soundness. Moreover, the scheme of organization adopted by the Academy provides that the several divisions of the Research Council shall be made up of nominees of leading national scientific and technical societies interested in research. This gives the Council a thoroughly representative character, and makes it an actual federation of research agencies. Thus it is peculiarly well fitted to secure the cordial coöperation of the numerous elements that must work in harmony, if extensive plans for coöperation in research are to be carried into effect.

Throughout the period of the war, the Research Council devoted all of its energies to the organization and conduct of research for military and industrial purposes.[2] In undertaking the larger activities rendered possible under peace conditions, the Council recognizes that one of its chief functions is to promote a wider appreciation of the national importance of scientific and industrial research. It is probably true that this task is less difficult in the United States than in any other country. The interest of the American public in scientific progress is unquestioned, and many of our great corporations have long since demonstrated their appreciation of the practical value of research. Notable illustrations, which will be fully described in *The Bulletin of the National Research Council* are afforded by the work of the great research laboratories of the American Telephone and Telegraph Company (Western Electric Company), the General Electric Company, the du Pont de Nemours Company, the Eastman Kodak Company, and the Westinghouse Company, to cite only a few outstanding examples. One of these corporations spends as much as three million dollars annually for research, and in all cases the resulting profits are so great that their laboratories and staffs of investigators are constantly expanding.

Parallel with this fast multiplying appreciation of research by industrial leaders, we find equally striking demonstrations that in other fields the importance of science and research have been widely felt. Tyndall, speaking in New York in 1873, at the conclusion of his very successful series of popular lectures on science, recognized both the opportunity and the need of that day:

> It would be a great thing for this land of incalculable destinies to supplement its achievements in the industrial arts by those higher investigations from which our mastery over Nature and over industrial art itself has been derived.

The great popularizer of science set an excellent example by devoting the proceeds of his lecture tour to the establishment of traveling fellowships for American students. "The willingness of American citizens to throw their fortunes into the cause of public education," cited by Tyndall as even then "without a parallel in my experience", has since led to the development of large universities, in many of which faculty members devote themselves to research to the full limit of their capacity. Heavily endowed research foundations have been established, and the research functions of Government bureaus have greatly increased. Thus the way has been cleared for new advances, which the unique conditions created by the war will certainly facilitate.

Optimistic as we may reasonably feel, however, in view of the progress already attained, we are in no danger of believing that our object has been already accomplished in any large degree. Many tendencies of the time indicate both the opportunity and the necessity for further effort. Not least of these is a widespread public preference for sensational discovery, even if based on little or no evidence, rather than for solid accomplishment of more sober sort. Pseudo-scientific journals, taken by thousands of enthusiastic amateurs, often feed their readers on the veriest nonsense in the guise of science. Charlatans offering fabulous wares are successful in securing appropriations from Congress. Such indications suffice to show the importance of rendering the sound results of scientific and industrial research more widely known, in language easily understood by all intelligent readers.

Again, we see many industries conducted on purely empirical lines, without the enormous advantages that scientific method would entail. The leaders of these industries are almost invariably ready to be convinced that their products could be improved and their profits increased by research, and the National Research Council is actively engaged in demonstrating the advisability of a general adoption of the research policy that has already proved so effective in many individual cases.

Finally, to mention here only one more direction in which effort must be made, we find those industries which have awakened to the importance of research, drawing from the universities and research foundations, by superior financial inducements, the men on whom we must depend for the fundamental contributions to knowledge from which industrial progress springs. Fortunately, such industrial leaders as Dr. J. J. Carty, vice-president of the American Telephone and Telegraph Company, have strongly emphasized the absolute necessity of cultivating science for the sake of advancing knowledge. It is plain that the skilled investigators needed in rapidly increasing numbers to man the laboratories of industrial research must be developed by the universities and schools of technology. But it is also clear that this draft on the supply of competent research men must not seriously deplete the ranks of those who are advancing knowledge. The universities should have ample means to support research, and the industries, especially those that profit most from science, should aid them by establishing research fellowships, professorships, and adequately endowed laboratories. Dr. Carty emphasized this view in his presidential address to the Institute of Electrical Engineers in 1916:

> By every means in our power, therefore, let us show our appreciation of pure science, and let us forward the work of the pure scientists, for they are the advance guard of civilization. They point the way which we must follow. Let us arouse the people of our country to the wonderful possibilities of scientific discovery and to the responsibility to support it which rests upon them, and I am sure they will respond generously and effectively.

The present *Bulletin* is the first of a series to be published by the National Research Council. It comprises the views of some of the members of the Advisory Committee of the Council on the national importance of scientific and industrial research. These statements are exceptionally significant, on account of the experience on which they are based. The Honorable Elihu Root, for many years Chairman of the Board of Trustees of the Carnegie Institution of Washington, has been in close touch with research in many fields. In surveying its possibilities in their broadest aspects, he has recognized the importance of securing a higher degree of organization, and much more effective coöperation among investigators than they have ever enjoyed. A superficial view of the matter might suggest the conclusion that organized effort in science would hamper the individual investigator and hinder personal initiative. It is only necessary to examine coöperative researches now in progress in astronomy, geology, and other fields in order to appreciate that the effect of well planned coöperation is to stimulate the individual and to bring out his best and most original effort. The National Research Council is strongly opposed to all attempts at central control of research, but favors the initiation of coöperative undertakings, provided that they be so devised as to encourage individual initiative. Future numbers of the *Bulletin* will illustrate possibilities of this nature.

The other statements in this *Bulletin* have also been prepared by well-known men familiar, through long experience, with scientific and industrial research. In pointing out the benefits that will accrue to those industries that utilize research most freely, they base their conclusions on practical results, of which they have personal knowledge. Manufacturers who have not yet recognized research laboratories as necessary adjuncts of their business will do well to ponder their advice, and inquire into the methods and successes of industrial research. The National Research Council will do everything in its power to facilitate such inquiries, both by publication in the *Bulletin* of accounts of research laboratories of many descriptions and by its series of research exhibits, designed to illustrate in a striking and effective manner the latest discoveries and advances in science and technology. The first of these exhibits, soon to be opened, will be devoted to the wireless telephone, which will be demonstrated in working form, and illustrated as the gradual outgrowth of researches planned, for the most part, without reference to any other object than the advancement of knowledge.

[1] See Hale, War Activities of the National Research Council, *Proceedings of the American Institute of Electrical Engineers*, July, 1918.

[2] See Third Annual Report of the National Research Council, transmitted to Congress in the *Annual Report for 1918 of the National Academy of Sciences.*

THE NEED FOR ORGANIZATION IN SCIENTIFIC RESEARCH*

By Elihu Root

Chairman of the Board of Trustees, Carnegie Institution of Washington

I have no justification for expressing views about scientific and industrial research except the sympathetic interest of an observer for many

*Washington, D. C., August, 1918.

years at rather close range. One looking on comes to realize two things. One is the conquest of practical life by science; there seems to be no department of human activity in which the rule of thumb man has not come to realize that science which he formerly despised is useful beyond the scope of his own individual experience. The other is that science like charity should begin at home, and has done so very imperfectly. Science has been arranging, classifying, methodizing, simplifying everything except itself. It has made possible the tremendous modern development of the power of organization which has so multiplied the effective power of human effort as to make the differences from the past seem to be of kind rather than of degree. It has organized itself very imperfectly. Scientific men are only recently realizing that the principles which apply to success on a large scale in transportation and manufacture and general staff work apply to them; that the difference between a mob and an army does not depend upon occupation or purpose but upon human nature; that the effective power of a great number of scientific men may be increased by organization just as the effective power of a great number of laborers may be increased by military discipline.

This attitude follows naturally from the demand of true scientific work for individual concentration and isolation. The sequence, however, is not necessary or laudable. Your isolated and concentrated scientist must know what has gone before, or he will waste his life in doing what has already been done, or in repeating past failures. He must know something about what his contemporaries are trying to do, or he will waste his life in duplicating effort. The history of science is so vast and contemporary effort is so active that if he undertakes to acquire this knowledge by himself alone his life is largely wasted in doing that; his initiative and creative power are gone before he is ready to use them. Occasionally a man appears who has the instinct to reject the negligible. A very great mind goes directly to the decisive fact, the determining symptom, and can afford not to burden itself with a great mass of unimportant facts; but there are few such minds even among those capable of real scientific work. All other minds need to be guided away from the useless and towards the useful. That can be done only by the application of scientific method to science itself through the purely scientific process of organizing effort. It is a wearisome thing to think of the millions of facts that are being laboriously collected to no purpose whatever, and the thousands of tons of printed matter stored in basements never to be read—all the product of unorganized and undirected scientific spirit. Augustus De Morgan, denying the divinity of Francis Bacon, says "What are large collections of facts for? To make theories *from*, says Bacon; to try readymade theories *by*, says the history of discovery; it is all the same, says the idolater; nonsense, say we." Whichever it may be, the solitary scientist is likely to put a great part of his life into the pathetic futilities illustrated by De Morgan in the *Budget of Paradoxes*. He needs chart and compass, suggestion, direction, and the external stimulus which comes from a consciousness that his work is part of great things that are being done.

This relation of the scientific worker to scientific work as a whole can be furnished only by organization. It is a very interesting circumstance that while the long history of science exhibits a continual protest against limitations upon individual freedom, the impulse which has called in the power of organization to multiply the effectiveness of scientific and industrial research to the highest degree is the German desire for military world dominion, supported by a system of education strictly controlled by government. All the world realizes now the immense value in preparing for the present war, of the German system of research applied at Charlottenburg and Grosslichterfelde. That realization is plainly giving a tremendous impetus to movements for effective organization of scientific power both in England and in the United States—countries whose whole development has rested upon individual enterprise. It remains to be seen whether peoples thoroughly imbued with the ideas and accustomed to the traditions of separate private initiative are capable of organizing scientific research for practical ends as effectively as an autocratic government giving direction to a docile amd submissive people. I have no doubt about it myself, and I think the process has been well begun in England under the Advisory Council of the Committee of the Privy Council for Scientific and Industrial Research, and in the United States under the National Research Council. I venture to say two things about it. One is that the work cannot be done by men who make it an incident to other occupations. It can be encouraged of course by men who are doing other things, but the real work of organization and research must be done by men who make it the whole business of their lives. It cannot be successful if parcelled out among a lot of universities and colleges, to be done by teachers however eminent and students however zealous in their leisure hours. The other thing is that while the solution of specific industrial problems and the attainment of specific industrial objects will be of immense value, the whole system will dry up and fail unless research in pure science be included within its scope. That is the source and the chief source of the vision which incidentally solves the practical problems.

We are thinking now mainly of science as applied to war; but practically the entire industrial force of mankind is being applied to war, so that our special point of view takes in the whole field. It is quite certain that if the nations on either side in this war had been without a great fund of scientific knowledge which they could direct towards the accomplishment of specific things in the way of attack and defense, transportation and supply of armies, that side in the war would long since have been defeated. Germany had the advantage at the start, because she had long been consciously making this kind of preparaion with a settled purpose to bring on the war when she was ready. It would be the height of folly for the peaceable law-abiding nations of the earth ever to permit themselves to be left again at a disadvantage in that kind of preparation. Competency for defense against military aggression requires highly developed organized scientific preparation. Without it, the most civilized nation will be as helpless as the Aztecs were against Cortez.

We are not limited, however, to a military objective, for when the war is over the international competitions of peace will be resumed. No treaties or leagues can prevent that, and it is not desirable that they should, for no nation can afford to be without the stimulus of competition. In that race the same power of science which has so amazingly increased the productive capacity of mankind during the past century will be applied again and the prizes of industrial and commercial leadership will fall to the nation which organizes its scientific forces most effectively.

THE FUNCTION OF SCIENTIFIC RESEARCH IN A MODERN STATE

By Henry S. Pritchett

President of the Carnegie Foundation for the Advancement of Teaching

The part played by scientific reseach in the development of modern nations is so well understood that it is a part of the common knowledge of mankind. What is perhaps not so well apprehended is the relation between the investigator in his laboratory or his library and the industrial and financial machinery through which his research is enabled to develop into forms which increase wealth, sustain human health and activity, and increase the comfort and security of human life. The world still conceives of scientific investigators in much the same light as the old time prospectors for the precious metals—each individual sinking his shaft here or there as chance or inclination may carry him. Of the great number so engaged a very few will strike veins of true gold, a larger number will obtain ore that will at least repay the labor and cost involved in their adventure, but the great majority will sink holes in barren and fruitless soil.

The prosecution of research today is upon an entirely different basis. Not only do those in the same science coördinate their work, if they are to attain the highest results, but all branches of science are regarded not as separate and unrelated agencies, but as parts of a common effort. A research started in a purely physical field may find its solution in a chemical reaction or a physiological process. The research men of a nation are not isolated individuals but an organized and coöperating army.

A striking illustration of the outcome of this conception is afforded by the history of the great industrial research establishment at Grosslichterfelde outside Berlin. In this vast establishment covering many acres, are brought together research men from every field of science working together in the solution of problems arising in the industries. A problem in textiles, or metals, or sanitation may require the coöperative efforts of men in fields of science that we ordinarily consider as foreign to each other. In the field of industrial research, chemistry, biology, mechanics, physics, are not separated and unrelated sciences, but parts of one universal science.

As a result of this coöperation the German manufacturer may take to this great research laboratory any problem of scientific industry. Manufacturers of steel, brass, stone, textiles, dyes, bring their difficult problems here to be solved. The first act of the administration is to put the enquirer abreast of the literature of the whole world. In many cases it will be found that the problem has already been solved somewhere, oftentimes for a purpose widely different from that of the particular enquiry that has called for the solution.

In the United States the relations between research men in the universities and institutes of research and those operating industrial plants have not yet come to a stage as intimate or fruitful as that which has existed for many years in Germany. It is today a part of our plan of progress for the future to establish such relations that the investigator and the manufacturer shall understand each other and shall coöperate intelligently for the promotion of science and industry.

RELATIONS OF SCIENCE TO INDUSTRY

By Theodore N. Vail

President of the American Telephone and Telegraph Company

It has been my desire to assist the National Research Council in bringing about closer coöperative relations between scientific and industrial effort and the more satisfactory coördination of the various sorts of research activity. I therefore welcome this opportunity to express my convictions concerning the importance of intimate relations between science and industry.

An immense amount of work has been done and is being done for the increase of knowledge through research. Much of this is wholly voluntary and isolated. Large results have followed but little has been accomplished by comparison with what can and will be achieved by the effective organizaton of effort. For such organization will at once reduce duplication of work and increase achievement through coöperation.

Scientific research is at the best costly in time and money because many wildernesses are necessarily explored without important results and many trails which lead nowhere are sure to be followed. But by carefully avoiding a duplication of work and by utilizing all that pioneer investigators have done the fruitfulness of research can be greatly increased. That this fact is recognized and widely accepted is indicated by present efforts toward organization.

What is now urgently needed is a clearing-house which shall be systematically organized to coördinate both scientific and industrial research. All investigators should be kept in intimate touch with such a clearing-house and through it the work of each should be made available to all. It should be one of the functions of this organization to promote the effective distribution and utilization of research information and in other feasible ways to minimize waste and promote the original work upon which progress chiefly depends.

Except for the special laboratories of a few large industrial organizations and the smaller laboratories of individuals, both scientific and industrial research have been carried on in the laboratories of educational institutions by individuals who are at once teachers and investigators. The combination of teaching and research should doubtless be continued, for it is profitable alike to student and teacher and tends to promote both research and scientific training. It is possible on the one hand for students to render valuable research assistance while studying in a college or university, and on the other hand it is almost inevitably true that contacts of the teacher with advanced students increase his value as an investigator. But already pure research has become so broad in its applications, and so insistently demanded by practical interests, that it constitutes an over heavy burden on educational institutions and must therefore be taken care of in a measure by the provision of special organizations.

Many educational institutions possess large and effectively organized laboratories with excellent staffs. It is not desirable that these organizations be ignored in the further promotion of research. Instead educational institutions should be financially aided in order that they may adequately provide for pure research both by material equipment and by the appointment of investigators whose time is not to any considerable extent demanded for other duties. Research laboratories, whether or not connected with educational institutions, should be freely open to the public and every effort should be made so to exhibit the importance of investigation that it shall be increasingly supported by the public.

The close connection in recent years between industrial progress and what may be called industrial research is significant. The large industrial enterprises have been developed as much through the organization of their scientific departments as through that of their operating departments. These departments of industrial research will undoubtedly be continued along present lines for, while their maintenance is costly in the aggregate, the expenditure is negligible by comparison with practical results when spread over a large production.

Many if not all of the large industries which have developed research departments started when the application of science to their particular needs was new. Consequently the industry and its corresponding research have developed together. But the progress of science during the past half-century has necessitated specialization in research as well as in production, so that today small and novel industries are unable to carry the burden of a highly organized research department. Unless something is done to meet the needs of such industrial establishments, a type of enterprise which has done much to advance civilization and to promote industrial progress will tend to disappear because of the impossibility of competing with larger and well established industrial organizations.

In short, the organization and coördination of research for industrial purposes is urgently necessary. Future progress is dependent upon prompt and wise action. Plans should be formulated at once with care.

Whatever is done should be national in its comprehensiveness and socialistic in its application. All should contribute and all should be able to avail themselves of the benefits of the research clearing house.

There is no question in my mind but that education and industry would greatly benefit by more intimate relations to research and through the promotion of scientific and industrial investigations. Industry may be expected to support generously any organization which promises to effectively coördinate and correlate efforts for the increase of knowledge, since it is now generally recognized that industrial progress and success are chiefly dependent upon knowledge.

COÖPERATION BETWEEN SCIENCE AND INDUSTRY

By Ambrose Swasey

President of the Warner and Swasey Company

The subject of industrial research is one of the most interesting and potentially perhaps the most valuable of all the material questions stimulated by the war.

The use of science in industry is not new in our country, nor in some of the other countries now at war; but the appreciation of the need for scientific and industrial research and the value of it has been tremendously developed by the stress of war conditions.

While it is true that the industrial life of our country has moved forward, during the years of peace, chiefly under the pressure of our needs or the enterprise and aggressiveness of individuals, yet many of our largest and most important industries owe their development principally to an understanding of the need for scientific study of their problems. Prominently among these must be listed the great electrical development in this country—a development based practically entirely upon the work of the scientist and the technician; our steel industry, with its by-product coke plants and all the products related thereto; the automobile industry with its relationship to metals; paints and varnishes; rubber and many other collateral lines; and latterly, the aeronautical field, which promises to lead us into undreamed-of achievements.

Without minimizing the accomplishments of the highly trained technical men in these industries, we can credit the great advances chiefly to scientific research, and the work of the technician, which has made applicable and practical the deductions of the scientist.

In these industries and many others, the study and conclusions of the scientist have made it possible for the labor of millions of people to be applied in a manner that, only a few years ago, would have been confined to a few specially trained individuals. To be specific, the development of the pyrometer makes possible the use of comparatively untrained workers on heat treatment, which formerly required the maximum of training and experience. The result of it all is to render to mankind those safeguards, conveniences, and comforts which formerly could be possessed only by a few fortunate people, if indeed, they existed at all.

The knowledge of the results accomplished in agriculture by national and state scientific investigation and coöperation is perhaps too widespread to make it necessary even to mention that subject.

The effort of the individual to better his own condition has received its chief aid from science. That the individual may be unaware of this does not alter the fact:

Our present duty is to decide how we shall meet the new situation, with plans wide and broad enough to assure the best results, without relinquishing any of the advance we have earned by years of effort and study.

In all of the countries now engaged in war the need for vastly increased quantities in all lines of production, with the necesssary curtailment in quantity available or change in character of raw material, has necessitated the adoption of new methods. The fundamental elements of each industry have been closely scrutinized, and old methods have given place to new with amazing rapidity. The nations will never resume the old methods; individual effort will continue to play the chief part; but coöperative effort, and to some degree, governmental action in directing and controlling research in industrial fields, has become essential. By no other means could we hope to meet the new world conditions which will follow the war.

If, after the war, other nations were to follow an easy-going industrial policy, it would possibly be a matter of indifference as to our national attitude. We would, however, be blind to the signs of the time if we should fail to recognize that the reverse is certain to be the case. 'Efficient industry' must be the watch-word of the future.

Nations have been stimulated by the war to their utmost endeavor, and science in coöperation with industry has been called upon to help rescue the world.

THE VALUE OF INDUSTRIAL RESEARCH

By A. W. Mellon

President of the Mellon National Bank of Pittsburgh

The recognition of the national essentiality of science, particularly chemistry, to the life of a nation has stimulated the industrialists to such a point that they are seeking at this particular time, as never before, to utilize every idea which makes for the advancement of industry. The aim of all industrial operations is toward perfection, both in process and mechanical equipment, and every development in manufacturing creates new problems. It is only to be expected, therefore, that the industrial investigator is becoming less and less regarded as a burden unwarranted by returns. Industrialists recognize, in fact, that manufacturing is becoming more and more a system of scientific processes; and probably no science has done so much as chemistry in revealing the hidden possibilities of the wastes and by-products of manufacturers. The present great advances are due entirely to the application of knowledge in the development of new things, which is primarily dependent upon systematic industrial research.

The industrialist, however, needs all possible assistance in undertaking and developing research work as a means of enlarging his output and improving its quality. In order to be effective it must increase his independence and initiative, and be so given as to enlist his active support. It has been the coöperation of progressive industry with science which has led to the practical application of the results obtained in the laboratories of scientific men. But, in this matter of the dissemination of knowledge concerning industrial practice, it must be evident to all that there is not complete coöperation between manufacturers and the technical schools. Manufacturers have been quite naturally opposed to publishing any discoveries made in their plants, since 'knowledge is power,' while, on the other hand, the technical schools exist for the diffusion of knowledge and from their standpoint the great disadvantage of the above policy is this concealment of knowledge. It results in a serious retardation of the general growth and development of service in its broader aspects and renders it much more difficult for the technical schools to train men properly for such industries. Fortunately, the policy of industrial secrecy is becoming more generally regarded in the light of reason and more liberal views are taken, which is bringing about a closer union between science and industry. It may, therefore, be taken for granted that the great corporations all over the country that have entered into such a scheme of coöperation with science have a vivid and comprehensive realization of the need of the efficiency which the scheme represents, and, incidentally, that the scheme itself is founded on sane and practical considerations.

Industrial research is, in fact, a very specialized business and, naturally, requires specially trained men and an understanding on the part of the industrialists as to its requirements and methods. The fundamental differences between pure research and industrial research are, indeed, traceable to the differences in the poise and personality of the representatives of each type of scientific investigation. Success in genuine industrial research presupposes all the qualities which are applicable to success in pure science, and, in addition, other qualities, executive and personal, more or less unessential in the pure research laboratory. At this point enters the real value of a system of coöperation between science and industry; the industrialist is aided by being taught the correct methods to follow and by guidance in the selection of the proper type of research men to carry on his work.

The individual manufacturer is not the only one to be benefited through well-established central research laboratories; as a general policy, 'Service to Industry' is exceedingly well carried out through work for associations, as the one laboratory is thereby enabled to serve practically all the manufacturers in any particular field at a very low cost to each manufacturer, and the benefits are received by some industrialists who otherwise would not feel able to support independent research work.

Manufacturers who have benefited by the application of science to industry have not been content to await chance discoveries but have established well equipped laboratories and strong research staffs. Moreover, some large industrial corporations have found it expedient to keep before the public the fact that investigations on a large scale ultimately bring considerable benefit to the community generally; that every scientific discovery applied in industry reacts to the public gain; and that consequently great industrial organizations are justified in the expenditure of large sums of money to carry on such investigations, since it is only where there are large aggregations of capital that the most extensive and productive research facilities can be obtained.

A spirit of coöperation should be encouraged among all types of research laboratories, as no greater good to society can arise than from a wider distribution of the duties and responsibilities of research. Accordingly, well established research laboratories should be willing to coöperate and render informative service necessary for the establishment and organization of other research laboratories.

We are now passing through a period which clearly brings to mind the fact that civilization unarmed by science is at a terrible disadvantage in a struggle for existence; and we must realize that this arming cannot be done at short notice.

CONCERNING THE IMPORTANCE OF INDUSTRIAL RESEARCH

By George Eastman

President of the Eastman Kodak Company

In the reorganization and readjustment of industry to the needs of the present time the extension of scientific research must play a great part. In recent years the application of research to industry has increased very greatly and manufacturing concerns of all kinds have organized research laboratories. These laboratories have up to the present been considered chiefly as auxiliaries to the producing departments. A business which established such a laboratory hoped to derive some direct benefits from the research work undertaken, to develop new products, to lower manufacturing costs, to overcome difficulties that arise. These hopes have generally been justified by the results that have been achieved, but it seems probable that the greatest value of industrial research lies rather in the indirect than in the direct benefits which flow from the association of science and industry.

Recent events have enabled us to realize that the effectiveness of an industrial organization depends upon knowledge, not only scientific knowledge but technical, commercial and financial knowledge, and the problem before us in developing our industry further is to arrange for the creation and distribution of wider knowledge in all departments.

By the very nature of its work an industrial research laboratory must become a focus and center of the technical knowledge of the industry. In our schemes for industrial development, therefore, we must direct our aim so that the laboratories established for research may create and systematize the technical knowledge relating to the industries with which they are associated, so that from the laboratories this knowledge may permeate all branches and sections of business life, raising the standard of aim and achievement alike in the manufacturing and commercial sides of industry, insisting on products of higher quality and simultaneously educating customers to make the best use of the products which are supplied to them.

Only by research and the systematic development of knowledge can we hope to attain to the true increase of wealth, an increase which affects the comfort and happiness of employed and of employer alike.

THE SIGNIFICANCE OF RESEARCH FOR MINING AND METALLURGY

By Walter Douglas
President of the Phelps Dodge Corporation

The extreme importance of industrial research in the successful conduct of great mining and metallurgical enterprises can be appreciated when it is realized that upon the development of certain scientific methods depends the commercial success of the production of metals from ores formerly regarded as valueless. The efforts of producers are directed toward economical means of extracting coal and metalliferous ores with the least possible loss consistent with safety to the miner, and the concentration and beneficiation of the raw material in such manner as to obtain the highest extraction of the valuable content. To this end, scientific investigation and experimentation are essential, and nearly all great, forward steps in industrial and technical advancement have originated in the research departments of the large producing companies. At this time, with foreign sources of supply of certain important elements curtailed through shortage of vessels, it is of special importance that means be devised to furnish certain substitutes or to utilize our own raw materials through the invention or perfection of processes by which production of commercial grades can be made available. Never before have the departments of industrial research assumed such importance to the basic industries of this country as they do today, and if we are to make ourselves independent of materials for which we have in the past relied on Germany, we must enlarge and elaborate our departments of research and investigation to an extent considered in the past as unnecessary and unjustified.

THE APPLICATION OF SCIENTIFIC RESEARCH TO ONE INDUSTRY

By JAMES R. MACCOLL

TREASURER OF THE LORRAINE MANUFACTURING COMPANY

It must be frankly admitted that in many industries the importance and value of scientific research have not been adequately grasped.

In the textile industry (particularly wool and cotton) twenty years ago there were probably no concerns large enough to carry on independent scientific research on a broad and liberal scale. In recent years, combinations have been formed—under one control—of groups of mills, and it would certainly be advantageous and profitable for these large concerns to make a liberal appropriation for scientific research, employing for this work men of ability who combine scientific training with sound, practical business ideas.

In addition, however, to these independent efforts, it would be of great benefit to the industry if there could be a coöperative movement organized by the National Research Council along with the leading textile schools and a committee of manufacturers to develop and supervise research and experiment in laboratory, textile school and factory.

The field is a broad one, beginning with the raw materials through all the processes of yarn-making, weaving, dyeing, printing, and finishing. It is a fact worthy of note at the present time that there is a large supply of faulty wool and low-grade cotton which can be purchased at relatively low prices compared with the better classes of wool and cotton which are in demand and in short supply. Here is a profitable field for research, and it is only one of many that could be enumerated.

The concentration of scientific minds upon research and experiment would undoubtedly be of vast benefit to the textile industry and to the welfare of mankind.

THE ORGANIZATION OF SCIENTIFIC AND INDUSTRIAL RESEARCH AT HOME AND ABROAD

By H. E. Howe

Vice Chairman, Division of Industrial Research, National Research Council

I. GENERAL STATEMENT

Research is not merely the collection of existing facts and data on a given subject; that is but an incidental though important phase of the work. One type of research creates new knowledge and gives new power over materials; the other type seeks to apply this newly created knowledge to the solution of specific problems. The two are really interdependent, equally complex and necessary.

For a number of years the world has been gradually developing a better appreciation of the scientific method and of scientific research largely because the benefits derived through its application to industry have been strikingly demonstrated. There are many examples of the commercial value of researches begun in pure science with no idea of immediate industrial application. Research therefore has been encouraged more and more, resulting in many discoveries of scientific and practical importance.

War is always a combat between two or more groups of resources and the most efficient utilization of these resources requires the proper application of science. This in turn involves the coördination of all facilities for research and applied science and frequently it has been shown that many serious difficulties were traceable to the failure to employ research previously. War has given great impulse to nearly all branches of science and one of our duties is to maintain and increase the momentum which has been gained.

Many of our war problems are associated with peace problems. Methods of manufacture, materials employed, principles to be mastered, are quite similar whether the product is one of peace or war, so that throughout the world it has come to be realized that we must continue to encourage, stimulate, and increase research in both pure and applied science if for no other reason than that we may make more and better things, understanding why as well as how it is done.

Attention is called to the present status of this world-wide movement.

II. UNITED STATES

In 1863, President Lincoln approved an act of Congress, incorporating fifty of the country's leading scientists under the designation of the National Academy of Sciences. One of the functions of the Academy was "to investigate, examine, experiment, and report upon any subject of science or art" whenever called upon to do so by any government department, but the Academy was to receive no compensation whatever for such services. The Academy served well during that emergency and on many later occasions has rendered valuable service to our government. Its by-laws have been modified at times and the number of its members increased.

In April, 1916, the Academy through its president offered to organize the scientific research of the country and the President of the United States accepted the offer and later approved the formation of the National Research Council, a body created to carry on this work. Later the Council was requested to act as a Department of Science and Research of the Council of National Defense, to organize a Science and Research Division of the Signal Corps and to carry out many other commissions for the military and naval establishments.

In order that the numerous problems might have the intensive study of specialists, the Council was organized along divisional lines, each division being composed of sections and special committees, upon which many of the country's foremost scientists served. The officers of the Council, the chairmen and vice-chairmen of divisions, and the chairmen of the sections of the General Relations Division, together with the elected members, made up an executive board which was assisted in its work by an interim committee. The divisions under the war organization were those of general relations, military, an important part of which was the research information service, engineering, physics, mathematics, astronomy and geophysics, chemistry and chemical technology, geology and geography, medicine and related sciences, agriculture, botany, forestry, zoölogy and fisheries.

Even a brief outline of the work accomplished could not be given here. Some of this work was done by the members themselves, some in laboratories throughout the country, and some in a purely advisory capacity, the Council or its sub-divisions acting as a clearing-house for information and helping to secure the necessary coöperation.

On May 11, 1918, the President issued an Executive Order in which it was stated that "the work accomplished by the Council in organizing research and in securing coöperation of military and civilian agencies in the solution of military problems, demonstrates its capacity for larger service." It was further requested that the National Research Council be perpetuated with duties which were set forth as follows:

1. In general, to stimulate research in the mathematical, physical and biological sciences, and in the application of these sciences to engineering, agriculture, medicine and other useful arts, with the object of increasing knowledge, of strengthening the national defense, and of contributing in other ways to the public welfare.
2. To survey the larger possibilities of science, to formulate comprehensive projects of research, and to develop effective means of utilizing the scientific and technical resources of the country for dealing with these projects.
3. To promote coöperation in research, at home and abroad, in order to secure concentration of effort, minimize duplication, and stimulate progress; but in all coöperative undertakings to give encouragement to individual initiative, as fundamentally important to the advancement of science.
4. To serve as a means of bringing American and foreign investigators into active coöperation with the scientific and technical services of the War and Navy Departments and with those of the civil branches of the government.
5. To direct the attention of scientific and technical investigators to the present importance of military and industrial problems in connection with the war, and to aid in the solution of these problems by organizing specific researches.
6. To gather and collate scientific and technical information at home and abroad, in coöperation with governmental and other agencies and to render such information available to duly accredited persons.

On a peace basis the Council's organization will be slightly different from the war time plan. It will consist of three classes of representatives: first, those of national scientific and technical societies; second, representatives of the government; and third, those of other research organizations and individuals whose aid may serve to advance the objects of the Council. The division method of organization will be followed with two principal classifications, (a) divisions concerned with the more general relations and activities of the Council, and, (b) those dealing with related branches of science and technology. Under the first class there will be six divisions; namely, government relations, foreign relations, states relations, educational relations, industrial research, and research information service. The divisions of science and technology will be seven in number; namely, physical sciences, engineering, chemistry and chemical technology, geology and geography, medical sciences, biology and agriculture, and anthropology and psychology.

The purpose of the Council may be stated as the promotion of research in the mathematical, physical and biological sciences and in the application of these sciences to engineering, agriculture, medicine and other useful arts, with the object of increasing knowledge, of strengthening the national defense, and of contributing in other ways to the public welfare, as expressed in the Executive Order quoted above. In carrying out this purpose, the Council endeavors in nowise to duplicate the efforts of other scientific bodies and strives to utilize to the fullest extent existing facilities for the prosecution of research, establishing laboratories only where no other course can be followed. A partial list of the non-military problems engaging the attention of the National Research Council is given in Appendix 1, page 33.

The National Research Council also endeavors to encourage research workers and to do what it can to increase the number of such workers in the country. To this end it has been entrusted with a fund of $500,000 by the Rockefeller Foundation, to be expended over a period of five years in the form of National Research Fellowships in chemistry and physics. It is hoped that these fellowships will make it possible to confirm a number of the most promising workers in research by enabling them to continue their research work immediately after taking their doctorates, at which time it is believed they are best qualified to continue any fundamental research. Some twelve appointments had been made at the time this was written, and with the return of large numbers of men to the universities and colleges, it is expected that a considerably larger number of appointments will be made in another year.

It will have been noted that the Council recognizes the importance of research in pure science and the application of the knowledge so acquired to the industries. Clearly one of its most useful activities will be that in connection with industry in which it hopes to promote a deeper sympathy for and appreciation of research.

III. THE BRITISH EMPIRE

a. Great Britain

Perhaps the outstanding difference between the National Research Council of the United States and the corresponding organizations elsewhere is that whereas foreign councils and departments, including the Department of Scientific and Industrial Research of Great Britain, are integral parts of their respective governments, the National Research Council enjoys the unqualified approval and full coöperation of the

United States Government, without being a part of the government organization.

In Great Britain the purposes to be accomplished are essentially the same as those in the United States, but there the government sets itself the problem of encouraging and organizing scientific research by direct state action.

In July, 1915, a committee was appointed by the Privy Council for the purpose of directing the application of any money provided by Parliament for the organization and development of scientific and industrial research, and an advisory council was created for the purpose of reporting and recommending proposals for research work as well as for initiation of proposals. In November, 1916, a charter of incorporation was granted to what is known as the Imperial Trust for the Encouragement of Scientific and Industrial Research, this trust having been established essentially to facilitate the work of handling money provided by Parliament and administering any other property or funds which may come into its possession. In December, 1916, the work of the committee first appointed was established under a separate department of state which has since been known as the Department of Scientific and Industrial Research. This department is responsible to a Minister of the Cabinet; namely, the Lord President of the Council because he is the only minister who has relations with the whole British Empire and it is recognized that if research is to be organized efficiently, it must concern the whole empire and that it ought to be possible to coöperate easily with similar departments or councils in other parts of the empire.

The field of work undertaken may be considered under three heads: first, the encouragement of research workers; second, the organization of research by industries; and, third, the organization of national research.

With respect to encouraging research workers, something over £3500 was spent during the academic year of 1916–1917 to assist those who had acquired enough knowledge to begin research or had shown some special capacity for such investigation. The amount spent in a similar way during 1917–1918 was £7500, and in 1918–1919 approximately £10,000. It is anticipated that this sum will amount to £30,000 during the next academic year. Careful records are kept of the performance of workers recommended by professors and others so that in the future their recommendations may be properly rated. The grants made are of four classes: first, for maintenance to enable students to be trained in methods of research. These are usually made for one year and are renewable for a second year. Second, for assistance to independent workers who devote their whole time to research whether in pure or applied science. These grants are also made for one year, but may be renewed for a further term of four years. Third, grants to teachers engaged in research to enable the employment of suitable assistants in research but not to act as teaching assistants. Fourth, allotments in special cases to a worker investigating some new branch of science to enable a research lectureship to be established pending the securement of endowment from other sources.

The Department of Scientific and Industrial Research has been particularly active in the organization of industrial research and has been provided by Parliament with a fund of £1,000,000 to enable it to encourage the industries to undertake research. A general policy has been adopted of allotting pound for pound to approved research associations which will engage in industrial research upon approved problems. The intention is to strengthen such research associations and assist them over the initial five year period, after which it is contemplated that the associations will be so firmly established that further government aid is not likely to be required.

These associations are usually limited to those concerns in a given industry or closely related to it or to various industries interested in the same problem or material but non-competitive. The Department gives whatever assistance it can to these associations, acts in an advisory capacity, serves as a clearing-house for information, and takes an active part in the prosecution of work without interfering in any way with the policies of the association.

Four associations are already at work, approximately fifteen more are completing their organization, and eleven others are in the earlier stages of formation. See Appendix II, page 37.

The organization of national research has gone forward along several lines and the Department has acted as a clearing-house of information for the various industrial research associations formed, has conducted investigations for other departments of the state, and has been active through research boards on problems, the solution of which belongs more to the government than to any private group. The investigations undertaken for other state departments have been at the invitation of the department interested, for the Department of Scientific and Industrial Research never knowingly enters a field in which work is under way without proper arrangements with those already concerned in that field. Among the investigations may be noted the question of mine rescue apparatus, and researches with reference to building materials, including home-grown timber.

Among the research boards the first to be established was that on fuel, and the government is spending large sums annually in the investigation of this very important problem. A special laboratory has been erected and it is in charge of a carefully organized staff of specialists. Later a food investigation board was formed, and then one on industrial fatigue research.

Early in 1918 the government assumed responsibility for the National Physical Laboratory, which corresponds, in a way, to the Bureau of Standards of the United States, and the growth of the Laboratory during the war can be best illustrated by comparing the total income of the Laboratory in 1913–14, when it was a little less than £44,000, with the budget for 1919–20 which is nearly £155,000.

Great Britain has proceeded vigorously with its research plans and a large number of important researches have been conducted through various agencies. Among these problems may be mentioned: optical and other scientific glass; tin and tungsten; tool steel; properties and composition of alloys; corrosion of non-ferrous metals in sea-water; refractories; hard porcelain; transformer and switch oils; treatment of high-speed steel; improved design of the cooling surfaces of aircraft motor cylinders; degumming of silk; deterioration of structural materials in sea water; various problems relating to dyeing; studies on fire prevention; investigation of the heating of buried cables; preliminary study of the flow of steam through nozzles; and the deterioration of super-heaters operating at high temperatures.

Some of the work which has actually been done is given in greater detail in Appendix II, page 36.

b. Australia

The Commonwealth Advisory Council of Science and Industry was established in March, 1916, and its purpose was the preparation of ground for the proposed permanent Institute of Science and Industry and starting the work of that permanent Institute. The preliminary work involved a census of Australian industries and of the problems connected with them; of the equipment and personnel of laboratories; of the research in actual progress; and of the facilities available for training men in scientific investigation. Relations were established with other state departments, with various educational institutions and scientific societies, and with the industries concerned. An effort was also made to encourage and coördinate the researches already in progress. A large number of special committees were appointed, most of which have now filed their final reports. The work covered by these committees was very diverse and the problems undertaken included: ferro alloys; yeast and bread-making; damage by insects to grain in storage; electrical sterilization of milk; utilization of native barks for tanning; alcohol fuel and engines; development of a mechanical cotton picker; substitutes for tin-plate; utilization of kelp; cold storage problems; tuberculosis in stock; by-products of wool-scouring; and a classification of imports of chemicals.

In July, 1917, a detailed plan for the permanent Institute was approved, and it was recommended that a permanent Institute should be established at once to undertake research, standardization, and the establishment of a bureau of information. While existing laboratories are to be utilized as far as possible, it is recommended that at least five national laboratories be established. These are: Plant Industry; Animal Industry; Industrial Chemistry and Metallurgy; Industrial Standards; and Forest Products.

The control of the permanent Institute is to be in the hands of three salaried directors, one of whom is to be a business man, the other two being chosen because of their scientific attainments. Each state of the Commonwealth is to appoint an Advisory Council and the Directors of the Institute are to meet each Advisory Council at least annually. The staff of the permanent Institute is to be appointed by the Governor-General on the recommendation of the Directors.

c. Canada

In June, 1916, the Privy Council of Canada appointed a committee to have charge of all measures relative to the scientific development of Canadian industries. Under this committee an Honorary Advisory Council for Scientific and Industrial Research, composed of eleven members, was constituted November 29, 1916, and established by Act of the Dominion Parliament in August, 1917. At that time $91,600 was voted for the fiscal year, and of this amount $12,000 was to be devoted to studentships and $5000 for fellowships in the educational institutions of the Dominion. To special problems $25,000 was assigned, and a preliminary grant of $600 was made for forest studies.

The plan is similar to that adopted in England. The administrative chairman is a permanent, salaried officer. The Council has charge of all matters affecting scientific and industrial research in Canada, assigned to it by the Sub-Committee of the Privy Council, and advises on questions of scientific and technological methods affecting the expansion of Canadian industries and the more efficient utilization of the natural resources of the country. The Council works in coöperation with various associations of scientists and manufacturers, and endeavors not only to encourage students to engage in research but to remain in the Dominion in industrial research.

The work in process is of a varied character, carried on principally by associate-committees in chemistry, mining and metallurgy. Upon these committees many scientists, government officials, and industrial men serve; in addition, British Columbia has appointed an Honorary Advisory Committee to coöperate with the Council. Council committees have been appointed to deal with such special problems as: hydro-power development; potash and phosphates; and temporary committees have undertaken the study of flax cultivation; cold storage; Fraser River salmon questions; plant and animal diseases; underground waters for the western plains. At the moment special attention is being given to the utilization of lignite through briquetting and otherwise.

The report of the Associate Committee on Chemistry for the year ending May 1, 1918, discusses seven major problems which the Committee had under consideration and a considerable list of special inquiries to which attention had been given. The researches assisted by the Council were ten in number.

The Council is now active in obtaining the establishment of a research institute similar to the Bureau of Standards of the United States, and has been granted some $400,000 for the continuation of the lignite studies. A census of the research facilities and the research man-power of the Dominion has been made and active steps are being taken to interest industries in the prosecution of research.

d. *India*

During the war the Indian Munitions Board stimulated industrial enterprises involving scientific and technical knowledge, and particularly those of direct value for modern warfare. It is the intention of the government that after the war this work will be carried on by an industrial board or department of the government in succession to the Munitions Board.

The Munitions Board pointed out that "munitions for a modern army cover practically all the ordinary wants of a civil community," and much has already been done to stimulate the tanning and textile industries, metallurgy, the manufacture of chemicals and of machinery, besides a number of miscellaneous undertakings.

e. New Zealand

Several proposals have been made looking to the organization of scientific and industrial research in New Zealand, and reports upon the subject are understood to be receiving the careful consideration of the government. The General Council of Education has prepared a plan for the adaptation of the educational system to the development of New Zealand resources. The plan provides for the establishment of a National Advisory Council on Research with four specific duties:

1. To allot all proposals for specific researches to the proper persons.
2. To study problems pertaining to particular industries and to determine the lines along which research shall proceed.
3. To award National Research Fellowships and Scholarships.
4. To advise the General Council of Education with reference to bringing about a general improvement in scientific education in order that specialists may be trained, and a better appreciation of the aims and advantages of science be obtained among producers, manufacturers, and the people generally.

f. South Africa

The South African Government has appointed an Industries Advisory Board. This was established in October, 1916, the members being almost entirely representatives of commerce, manufacturing and labor. In February, 1917, this Board recommended the appointment of a Scientific and Technical Advisory Committee to deal with all scientific and technical matters and questions of research which would be referred to them by the Industries Advisory Board. A committee of ten members was accordingly appointed, and this committee has undertaken, in addition to providing for industrial research, to coördinate industrial investigations and research in South Africa, and to collect and disseminate data emanating therefrom. They also undertook coördination with other government departments and with similar departments of the United Kingdom to obtain available information, to avoid duplication, and to take advantage of facilities for research not available in South Africa. An economic survey of natural resources, and advice relating to the best methods of their utilization; advice relative to methods of attacking industrial problems; the coördination of various industries and the exchange between user and manufacturer of improvements and experience, were among their other activities. Educational work, including lectures, publications and museums, and the standardization of scientific and industrial qualities affecting the efficiency of production and the accuracy of statistics, have also had their attention.

IV. FRANCE

In France the progress in the establishment of a national council has not been as rapid as elsewhere. The question of national laboratories of scientific research was made the subject of a report by a committee of the Paris Academy of Sciences in November, 1917. France has had no institution corresponding to the Bureau of Standards of the United States, the National Physical Laboratory in England, or the State Laboratories in Germany, and the Academy of Sciences, being convinced of the necessity of organizing systematic scientific researches in France, expressed its wish that a National Physical Laboratory should be founded for the prosecution of research useful to the progress of industry. The Academy suggests that such a laboratory should be placed under its control and direction working through a Council, one-half of whose members would be nominated by the Academy, one-quarter representing the State Departments, and the remaining delegated by industrial interests.

A school for applied optics, supported by a combination of government and private funds, has been established for the purpose of stimulating the study of optics and the manufacture of optical instruments.

V. ITALY

Early in 1916 the Office of Inventions and Research was created as a Department of the Ministry of Arms and Munitions and was organized under Senator V. Volterra. That Office served with distinction during the war and an Italian National Research Council is now in process of formation. Its objects will be:

(a) To further researches in the sciences and in the application of these to industry, agriculture, hygiene, alimentation and to national defense.

(b) To formulate and accomplish concrete projects of researches, in order to utilize the scientific, technical and natural resources of the country.

(c) To furnish technical or scientific information as required by public administrations and perform experimental and theoretical researches as asked for by the same administrations.

(d) To establish constant liaison by means of Italian and foreign delegates (Scientific Attachés to the Embassies) with similar foreign institutes so as to furnish information on the scientific and technical work of foreign countries and promote, in this way, researches and associations of international character.

(e) To furnish to the Army and Navy scientific, technical and industrial data relating to the national defense.

The Council will be divided under seven general headings as follows: (a) mathematical sciences and sciences of observation and measurement;

(b) mechanics and engineering; (c) physics and its applications; (d) chemistry and its applications; (e) aerodynamics and its applications; (f) mineralogy, geology and mining; (g) biological sciences and their applications especially those relating to agriculture and technical zoölogy.

In addition, there will be divisions especially concerned with national defense, patents, and coöperation with other countries. The Council will be made up of representatives from various State Departments, representatives of scientific and industrial bodies and unattached individuals. It is intended to use existing research facilities in educational and industrial plants, but also to establish special laboratories if need is found for them. It is expected that the government will appropriate a million lira for the support of the work of the Council, this being added to the budget of the Minister of Industries. Under this Department the Council will carry on its work.

VI. JAPAN

In Japan steps have been taken for the establishment of a National Laboratory for scientific and industrial research, the National Physico-Chemical Institute of Japan. The work of this laboratory will be the development of Japanese industries through the application of modern methods and the results of researches which are to be undertaken. The various sections of the laboratory will be devoted to such subjects as the following: (a) electricity and electro-chemistry; (b) lighting; (c) scientific apparatus; (d) drugs, dyes, perfumes, rubber, etc.; (e) artificial or imitation silk; (f) foodstuffs and beverages; (g) refrigerating methods; (h) oils; (i) fixation of atmospheric nitrogen; (j) utilization of fumes for metallurgical works; (k) prevention of explosions in coal mines; (l) microscopic research with iron and steel; (m) steam turbines; (n) resistance, power, and speed of ships; (o) arms and ammunition; (p) fire-proof and earthquake-proof buildings. Young men of promise in research are being appointed to fellowships and sent abroad.

Approximately two and a half million dollars has been set aside to support the laboratory over a period of ten years. Control will be placed in the hands of a General Council consisting of fifty members and the organization is to be made a part of the Department of Agriculture and Commerce.

VII. BELGIUM

The establishment of a National Research Council is under consideration by the Belgian Government.

VIII. INTERNATIONAL RESEARCH COUNCIL

Through the initiative of the National Academy of Sciences—particularly its Foreign Secretary, Dr. George E. Hale—a plan has been perfected for the establishment of an International Research Council, to be composed of representatives of the Research Councils or similar bodies in the allied and neutral countries. This international body will have a vice-president for each country represented, and will be organized upon divisional lines very much as the National Research Council of the United States is now organized. It will consider principally those problems which have international importance, such as certain questions in astronomy, geophysics, medicine and related sciences. It will also serve to disseminate knowledge and coördinate much of the research undertaken by various organizations in different parts of the world in such a way that greater progress seems certain. At the meeting held in Brussels in July details of arrangement were perfected and the various divisions will shortly announce their organization and program for work. It is contemplated that the International Research Council will perform the functions of some of the international associations which have heretofore been in operation.

IX. APPENDIX 1

Partial list of non-military researches undertaken by the National Research Council:

Engineering Division

Pyrometer.
Making of steel ingots.
Fatigue of metals.
Saving of manganese.
Electric welding.
Improvement of metals at blue heat.
Elimination of inclusions from steel.
Elimination of sulphur in open hearth practice.
Electric insulation.
Hardness testing machine.
Neumann bands.
Production of metallic beryllium.
Pulverizing.
Standardizing of bearing metals.
Substitute oxidizers.
Uses of alloy steels.
Uses of tellurium and selenium.
Uses of cadmium.
Airplane motors.
Carburetors.

Airplane fuels.
Locking differential for motor trucks.
Walking-beam tractor.
Airplane propeller.

Division of Chemistry and Chemical Technology

Chemical properties of the following:
  Soils.
  Fertilizers.
  Rubber and allied substances.
  Fuels and combustion.
  Ceramics.
  Synthetic drugs.
  Dyestuffs and textiles.
  Colloids.
  Nitrogen fixation.
Sewage disposal.

Division of Medical Sciences

A. Under direction of the Executive Committee of the Division:
  The development of protectors for the ear against effects of high explosives.
  New methods for the production of acetone.
  General testing of new antiseptics and special study of application of the same.
  Studies of anaerobic bacteria of importance in war wounds.
  The cultivation, collection and pharmacological study of native medicinal plants.
  Determination of substitutes for ambrine.
  A study of gases as disinfectants of wounds and their use to render disease carriers innocuous.
  Sterilization of drinking water for large bodies of troops.
  A critical study of methods of small-pox vaccination on a large scale.
  The value of the agglutination test after vaccination against typhoid fever.
  A study of rare and unusual sugars in the different strains of pneumococcus, streptococcus, and meningococcus.
  A study of hemostatic preparation.
  Studies of peripheral nerve injury and repair, with special reference to the prevention of amputation neuromata.
  Studies of streptococcus infection, with special reference to empyema.
  A study of possible substitutes for the petri dish.
  War edema among infants.
  Chemotherapeutic studies of experimental pneumococcus infection.
  Tests to devise a gauze mask effective in the prevention of droplet infection.
  A study of the cause of the so-called Spanish influenza and its possible prevention by vaccination.
  Studies on transmission of measles.
  Tests of the influence of slow intravenous injections of foreign serum in the prevention of anaphylactic shock with special reference to the army use of antitoxic sera.
  Chloralose as a general anesthetic in cases of shock.
  Skin grafting as conditioned by the blood group of donor and recipient.
  The use of "immunized" skin grafts in infected wounds.
  Gentian violet as an antiseptic for "preserved blood" used in transfusions.
  Methods to increase the yield of serum-antibodies in immunized animals.
  A simplified and improved apparatus for transfusions.

A study of the importance of antiagglutinins for transfusion.
A test to disclose oxygen-lack in the air of submarines and mines.

B. Committee on industrial poisonings:
  An experimental study of toxic effects of substances entering into the manufacture and handling of explosives.
  A study of early signs of intoxications among munitions workers.
  A study of airplane "dopes."
  The development of protective varnishes or other skin coverings.

C. Committee on toxicity of preserved foods:
  Studies of canning and other methods of preserving food.
  The related problems of botulism.

D. Committee on neurology and psychiatry:
  An analysis of 13,000 records of soldiers discharged from service on account of nervous and mental disturbances.
  The early histological lesions of meningoencephalitis. (From material of the Army Medical Museum.)

E. Committee on the study of the physiology of shock:
  Twenty-nine studies in 10 stations.

F. Committee on control of hemorrhage.

G. Committee on fatigue in industrial pursuits:
  An investigation of hygienic conditions in industrial establishments.
  Studies of industrial efficiency.
  Physiological studies of fatigue.

H. Committee on Biochemistry:
  Studies of varieties of velvet bean and of its utilization as a food.
  Substitutes for cane sugar.
  The minimum vitamin requirement.
  Substitutes for acetone in extracting and drying.

I. Anthropology committee:
  A study of central European races in New York City.
  Race in relation to physical conditions and fitness for employment.
  Anthropometric study of drafted men.

J. Psychology committee:
  Twenty studies by 12 different observers (or groups of observers) of military problems to which the methods of psychology are applicable.

K. Medical zoölogy:
  Studies of Giardia Microti.
  The treatment of experimental Giardiasis.
  An improved method of detecting ova of parasites in stools.
  Hookworm investigations.
  Louse investigation.

Division of Biology and Agriculture

Studies of native woods.
Fertilizers.
Poultry Feeding.
Protein metabolism in animal feeding.
Rats, mice and rodent pests.
Salt requirements of cultivated plants.
Sizing materials.
Salting fish in southern climates.
Lac and lac insects.

X. APPENDIX 2

In order that work actually accomplished may be contrasted with what has been proposed, we invite attention to the following details with reference to the success of the Department of Scientific and Industrial Research in Great Britain.

The first report calls attention to the following researches which had enjoyed the aid of the Department. Laboratory glass; optical glass; refractory materials; hardness testing for journals and pins; properties and composition of alloys; flow of steam through nozzles; heating of buried cables; properties of insulating oils; tool steel experiments; methods of notched bar impact testing; corrosion of non-ferrous metals; hard porcelain; setting and disintegration of salts and crystalline substances; degumming of silk; tin and tungsten; deterioration of structures of timber, metal, and concrete in sea-water; rate of heat transmission from hot surfaces to fluids over them; and statistical work in preparation of field for research in iron and steel.

Much of this work is carried on in educational institutions, in the National Physical Laboratory, and in certain private laboratories. The rapidity with which plans for the promotion and application of research developed is readily illustrated by the breadth of the program outlined in the second report, which announced the million pounds set aside by the government for trade research associations. The work of the Fuel Board, outlined in that report, involved taking stock of the coal resources of each district in Great Britain, classifying the seams according to their qualities, and ascertaining particularly the industrial uses to which the different kinds of coal were being put or in what way they could best be utilized. Peat has also received careful attention with reference to the bogs in Ireland and the most efficient methods of digging, preparing, and using peat for fuel and other purposes. The Board further gave advice as to the standards of quality for town gas and assisted the various Departments of State interested in the supply of fuel of various kinds and its most effective use. Better methods of domestic heating and improvement of ventilation of dwelling houses has formed another phase of the Fuel Research Board's activity, and five researches on domestic heating have been carried out at University College, London. An effort has been made to establish coefficients of heat transmission through standard building materials and to conduct investigations on heat transmission from radiators.

Another field of endeavor has concerned atmospheric pollution and the causes producing it, its effects on public health, buildings, etc., and the value of various means of counteracting it.

Mine rescue apparatus has received special attention, and careful inquiry has been made into types of breathing apparatus used in coal mines, and experiments have been conducted to determine the advantages, limitations, and defects of the several types of apparatus with a view to improving them if possible. Conditions in deep and hot mines have received attention with reference to the influence of hot and moist atmosphere on miners and the possible methods to be employed for cooling and drying the atmosphere in deep mines.

The Concrete Institute, with the aid of the Department, has undertaken a series of carefully regulated tests of concretes made from various local aggregates, the researches being conducted at nine colleges and universities.

A new institute of technical optics has been formed, and because of the deficiency of books in the English language on geometrical and technical optics, a new series of optical text books in English has been initiated.

Surveys of resources have been made, and of the fields for research, and the plan for the formation of coöperative industrial research associations has met with marked encouragement.

Some thirty industries have taken steps to establish these research associations. Three have been licensed, namely, the British Photographic Research Association, the British Scientific Instrument Research Association, and the British Wool Research Association. In addition to these, the cotton industry, the Portland cement manufacturers', the India rubber manufacturers', and the motor and allied manufacturers' research associations are approaching completion. Among other branches of industry which are engaged in drafting articles for the respective associations may be mentioned pottery, mining, iron manufacture, non-ferrous metals, baking and silk.

All of these associations with the exception of the iron manufacturers are being formed on the general plan of the government sharing the expense of the work equally with the association, but in the case of the iron manufacturers they have subscribed all of the necessary funds, and by avoiding any claim upon the government for assistance in their finances, they avoid that measure of regulation which is inseparable from the use of government funds. The Iron Manufacturers' Research Association proposes that not only shall all the results of the researches undertaken be freely available to each firm, but that all existing knowledge, trade secrets, and processes shall be pooled for the common good of the trade. This is a policy which some associations will hesitate to adopt, but it is expected that much of profit will be derived from the policy.

Inasmuch as these associations are formed to work without paying a profit, the Board of Inland Revenue has instructed the Surveyors of Taxes to allow as a working expense for income tax purposes the contributions made to industrial research associations formed for the purpose of scientific research for the benefit of the various trades. There are certain safeguards, but since this decision includes war profits and excess profit taxes, it offers a considerable inducement to firms affected by these taxes to join such associations promptly and support them in a substantial manner.

An excellent example of the thoroughness with which the preliminary work in the formation of such research associations has been conducted is the British Cotton Industry Research Association. In that instance an excellent booklet has been issued calling attention to the dependence of the cotton industry upon research for its further progress, and pointing out that in no other way can English manufacturers hope to maintain the lead in the cotton industry. Emphasis is placed upon the fact that whereas we insure against all sorts of financial loss and calamity, in most instances the manufacturer and the industry are not adequately insured against greater losses due to ignorance, and that such insurance can be had only by consistent and continued support of scientific and industrial research.

XI. APPENDIX 3

Below is quoted the Memorandum of Association which has been suggested by the British Department of Scientific and Industrial Research for the use of those forming research associations.

Memorandum of Association of The British Research Association

1. The name of the Association is 'The British Research Association.'

2. The registered office of the Association will be situate in England.

3. The objects for which the Association is established are:—

(a) To promote research and other scientific work in connection with the . . . . trade or industry and other trades and industries allied therewith or accessory thereto, and for that purpose to establish, form, equip and maintain laboratories, workshops or factories, and conduct and carry on experiments, and to provide funds for such work, and for payment to any person or persons engaged in research work, whether in such laboratories or elsewhere, and to encourage and improve the education of persons who are engaged or are likely to be engaged in the industry.

(*b*) To prepare, edit, print, publish, issue, acquire and circulate books, papers, periodicals, gazettes, circulars and other literary undertakings treating of or bearing upon the said trades or industries or any of them and to establish, form and maintain museums, collections, libraries and collections of literature, statistics, scientific data and other information relating to the said trades or industries or any of them or to matters of interest to the Members thereof, and to translate, compile, collect, publish, lend and sell, and endeavour to secure, or contribute to, the translation, compilation, collection and publication, by Parliament, Government Departments and other bodies or persons, of any such literature, statistics and information, and to disseminate the same by means of the reading of papers, delivery of lectures, giving of advice, the appointment of advisory officers or otherwise.

(*c*) To retain or employ skilled, professional or technical advisers or workers in connection with the objects of the Association, and to pay therefor such fees or remuneration as may be thought expedient, also to found, aid, maintain and endow scholarships and bursaries for the remuneration, instruction and support of students in research work, or persons engaged in studying the principles involved in any of the said trades or industries or connected therewith, whether in the laboratories of the Association or elsewhere, and to employ and remunerate as may be expedient, instructors and supervisors for such students and also for persons engaged in studying the principles involved in any of the said trades or industries or connected therewith, paying due regard to the provision of instruction by existing institutions.

(*d*) To encourage the discovery of, and investigate and make known the nature and merits of inventions, improvements, processes, materials and designs which may seem capable of being used by Members of the Association for any of the purposes of the said trades or industries or any of them and to acquire any patents or licenses relating to any such inventions, improvements of processes, and to acquire and register any designs or standardisation marks, whether for general or special purposes, with a view to the use thereof by Members of the Association and others upon such terms as may seem expedient, and to develop, perfect and test the value of such inventions, improvements, processes and designs by manufacturing, exhibiting and placing on the market any article or substances to which the same may be capable of application.

(*e*) To apply to the Government, public bodies, Urban, Local, Municipal, County and other bodies, corporations, companies or persons for, and to accept grants of money and (subject to Section 19 of the Companies (Consolidation) Act, 1908) of land, donations, gifts, subscriptions and other assistance with a view to promoting the objects of the Association, and to discuss and negotiate with the Committee of the Privy Council for Scientific and Industrial Research and other Government Departments, public and other bodies, corporations, companies or persons, schemes of research and other work and matters within the objects of the Association and to conform to any proper conditions upon which such grants and other payments may be made.

(*f*) To establish, promote, coöperate with, become a member of, act as, or appoint trustees, agents or delegates for, control, manage, superintend, afford financial assistance to, or otherwise assist the research work of any associations and institutions and other bodies incorporated or not incorporated, whose objects include scientific or industrial research.

(*g*) To establish, maintain, control and manage branches of the Association in the United Kingdom and elsewhere as may seem expedient, and from time to time to determine the constitution, rights, privileges, obligations and duties of such branches, and, when thought fit, to dissolve and modify the same.

(*h*) To undertake and execute any trusts which may be conducive to any of the objects of the Association.

(*i*) To carry out any of the above-mentioned research or other scientific work, and to do all or any of the above-mentioned things whether affecting the whole of the said trades or industries or merely one or more particular parts or sections of the said trades or industries or any of them or the business of any particular member or group of members of the Association, and, in the case of work not affecting the whole of the said trades or industries, to make such arrangements as to special payment by such particular sections or members or groups of members as may be expedient.

(*j*) To borrow or raise any money that may be required by the Association upon such terms as may be deemed advisable, and in particular by the issue of bonds, debentures, bills of exchange, promissory notes or other obligations or securities of the Association, or by mortgage or charge of all or any part of the property of the Association.

(*k*) To draw, make, accept, indorse, discount, execute and issue promissory notes, bills of exchange and other negotiable or transferable instruments.

(*l*) To invest the moneys of the Association not immediately required in any one or more of the modes of investment for the time being authorised by law for the investment of trust moneys and in such manner as may from time to time be determined.

(*m*) Subject to the provisions of the 19th Section of the Companies (Consolidation) Act, 1908, to purchase, take on lease or in exchange, hire or otherwise acquire any real and personal property, and in particular any land, buildings, workshops, factories, laboratories, machinery, plant, apparatus, appliances and any rights or privileges necessary or convenient for the purposes of the Association, and to construct, erect, alter, improve and maintain any buildings which may be from time to time required for the purposes of the Association, and to manage, develop, sell, demise, let, mortgage, dispose of, turn to account or otherwise deal with all or part of the same with a view to the promotion of the objects of the Association.

(*n*) To pay all expenses, preliminary or incidental to the formation of the Association and its registration.

(*o*) To use the funds of the Association in the employment of persons of learning or skill, and the provision and use of buildings, and of instruments, materials and appliances, and of any of the equipment of the Association for any form of scientific studies which may be considered to have some bearing, whether immediate or ultimate, on practical problems involved in the nature or use of . . . .

(*p*) To collect, arrange, index and publish information as to materials, patents, processes, machines, appliances and tools used or known in or in regard to . . . . or the said trades or industries or likely to be useful thereto, and to establish and maintain a Bureau of Information for the benefit of members of the Association.

(*q*) To establish and support or aid in the establishment and support of Associations, institutions, funds, trusts and conveniences calculated to benefit employees or ex-employees of the Association or the dependents or connections of such persons, and to grant pensions and allowances to and to make payments towards insurance of such persons.

(*r*) To procure the Association to be registered or recognised in any part of the British Empire or in any foreign country or place.

(*s*) To do all such other lawful things as may be incidental to or conducive to the attainment of the above objects.

Provided always that nothing herein contained shall empower the Association to carry on the business of life assurance, personal accident assurance, fire insurance or employers' liability insurance or the business of insurance within the meaning of the Assurance Companies Act, 1909, Section 1.

Provided also that the Association shall not support with its funds any object, or endeavour to impose on or procure to be observed by its Members or others any regulation, restriction, or condition, which, if an object of the Association, would make it a trade union.

Provided also that in case the Association shall take or hold any property subject to the jurisdiction of the Charity Commissioners or Board of Education for England and Wales, or any authority exercising corresponding jurisdiction outside England and Wales, the Association shall not sell, mortgage, charge or lease the same without such authority, approval or consent as may be required by law, and as regards any such property the Managers or Trustees of the Association shall be chargeable for such property as may come into their hands and shall be answerable and accountable for their own acts, receipts, neglects and defaults, and for the due administration of such property in the same manner and to the same extent as they would as such Managers or Trustees have been if no incorporation had been effected, and the incorporation of the Association shall not diminish or impair any control or authority exerciseable by the Chancery Division, the Charity Commissioners, or the Board of Education or any such other authority as aforesaid over such Managers or Trustees, but they shall, as regards any such property, be subject jointly and separately to such control or authority as if the Association were not incorporated. In case the Association shall take or hold any property which may be subject to any trusts, the Association shall only deal with the same in such manner as allowed by law having regard to such trusts.

4. The income and property of the Association, whencesoever derived, shall be applied solely towards the promotion of the objects of the Association as set forth in this Memorandum of Association, and no portion thereof shall be paid or transferred directly or indirectly, by way of dividend, gift, division, bonus or otherwise howsoever by way of profit, to the Members of the Association.

Provided that nothing herein shall prevent the payment in good faith of reasonable and proper remuneration to any officer or servant of the Association or to any member of the Association, in return for any services actually rendered to the Association, or for any material, labour, plant or power supplied for experimental purposes, nor prevent the payment of interest at a rate not exceeding six per centum per annum on money lent, or payment of a reasonable and proper rent for premises demised or let by any Member of the Association, but so that no member of the Council or Governing Body of the Association shall be appointed to any salaried office of the Association or any office of the Association paid by fees, and that no remuneration or other benefit in money or money's worth shall be given by the Association to any Member of such Council or Governing Body except by way of repayment of out-of-pocket expenses and interest at the rate aforesaid on money lent or the payment of a reasonable and proper rent for premises demised or let to the Association (or any remuneration to any member of the Council in accordance with any recommendation by or with the approval of the Committee of the Privy Council for Scientific and Industrial Research), provided that nothing hereinbefore contained shall prevent any payment to any Railway, Gas, Electric Lighting, Water, Cable or Telephone Company of which a member of the Council may be a member, or to any corporate body of which a member of the Council may be a member or shareholder holding less than one-hundredth part of its capital or to any other corporate body or to any firm with the previous consent of the Committee of the Privy Council for Scientific and Industrial Research, and Members shall not be bound to account for any share of profits they may receive in respect of any such payment.

Provided also that nothing herein shall prevent any Member of the Association, whether a member of the Council or not, from exercising any processes and making, using, acquiring and vending any articles and things in the ordinary course of his business for profit or otherwise under any license or permission in respect of any discovery, invention and patents resulting from the work of the Association.

5. No addition, alteration or amendment shall be made to or in the regulations contained in the Articles of Association for the time being in force, unless the same shall have been previously submitted to and approved by the Board of Trade in consultation with the Committee of the Privy Council for Scientific and Industrial Research.

6. The fourth and fifth paragraphs of this Memorandum contain conditions on which a license is granted by the Board of Trade to the Association in pursuance of Section 20 of the Companies (Consolidation) Act, 1908.

7. The liability of the Members is limited.

8. Every Member of the Association undertakes to contribute to the assets of the Association, in the event of the same being wound up during the time that he is a Member, or within one year afterwards, for payment of the debts and liabilities of the Association contracted before the time at which he ceases to be a Member, and of the costs, charges and expenses of winding up the same, and for the adjustment of the rights of the contributories amongst themselves, such amount as may be required not exceeding £5.

9. If upon the winding up or dissolution of the Association there remains, after the satisfaction of all its debts and liabilities, any property whatsoever, the same shall not be paid to or distributed among the Members of the Association, but shall be given or transferred to some other institution or institutions having objects similar to the objects of the Association, and which shall prohibit the distribution of its or their income and property amongst its or their Members to an extent at least as great as is imposed on the Association under or by virtue of Clause 4 hereof, such institution or institutions to be determined by the Members of the Association, subject to the approval of the Committee of the Privy Council for Scientific and Industrial Research at or before the time of dissolution, or in default thereof by such Judge of the High Court of Justice as may have or acquire jurisdiction in the matter, and if and so far as effect cannot be given to the aforesaid provision, then to some charitable object.

10. True accounts shall be kept of the sums of money received and expended by the Association, and the matters in respect of which such receipts and expenditure take place, and of the property credits and liabilities of the Association, and, subject to any reasonable restrictions as to the time and manner of inspecting the same that may be imposed in accordance with the regulations of the Association for the time being, shall be open to the inspection of the Members. Once at least in every year the accounts of the Association shall be examined, and the correctness of the balance sheet ascertained by one or more properly qualified auditor or auditors.

Bulletin of the National Research Council

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